THE EYE OF CRYPTOBRANCHUS.

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Since no investigations, apparently, have been made on the anatomy of the eye of the American giant salamander, *C. alleghenienesis*, a brief description of that organ may be of interest.

In the living animal the eyes are quite inconspicuous, due to their small size, their lack of bright coloration, and to the wrinkled condition of the skin that surrounds them. The pupil, as seen from the surface, is very irregular in outline ; it appears as a small, jagged, black spot in the center of the gray iris. The eyes of the living *Cryptobranchus* do not differ markedly in appearance or relative size from those of *Necturus*.

In order to study their structure, the eyes, with a little of the surrounding tissue, were removed and sectioned in colloidin. Owing to the hardness of the lens it was not possible to cut very thin sections. The tissue was stained *in toto* with borax carmine, and after the sections were arranged serially on the slides they were stained with Lyon's blue. The memorandum as to fixation having been lost, it is not possible to give the method, but the results were fairly satisfactory except in the case of the layer of rods and cones of the retina. The figure represents a section through the middle region of the eye, passing through the optic nerve and the pupil.

The sclerotic coat (*Sc*) is rather indefinite in extent, and is largely chondrified. This cartilage forms a very thick capsule that surrounds considerably more than half of the globe of the eye. It is perforated, of course, at the back for the passage of the optic nerve. The walls of the cartilaginous capsule are not of homogeneous structure throughout, but are penetrated at places by ingrowths of tissue apparently derived from the choroid (*Ig*). The unchondrified portion of the sclerotic is, as has been said, of rather indefinite amount. It extends in front of the eye, between it and the superficial epithelium, to form a comparatively thick and, one would think not very transparent, cornea (*C*). In the fibrous portions of the sclerotic, as in other parts of the

eye, are frequently seen large, black, many-branched pigment cells (*Ps*).

The corneal epithelium (*E*) is a direct continuation of the general epithelium of the head, there being no lids. As seen in the figure, the corneal epithelium is somewhat thinner than that of the rest of the head, and is composed of several layers of small cells with strongly-staining nuclei; the nuclei of the deepest layer are somewhat larger than the more superficial ones.

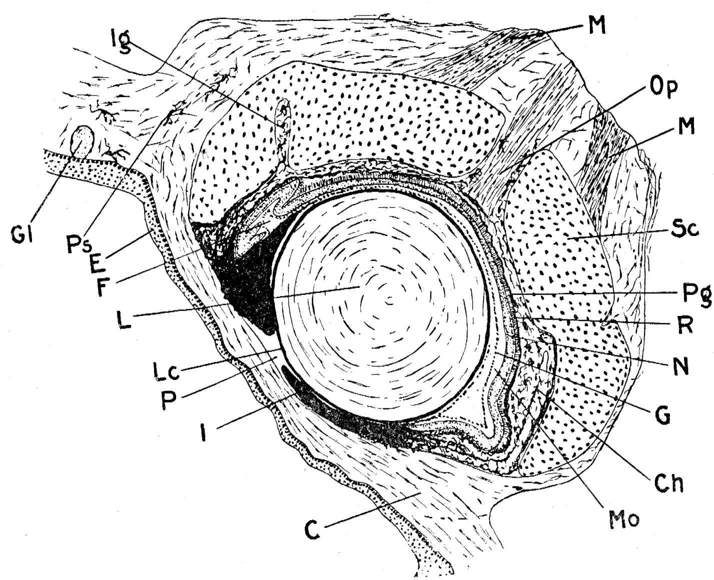

FIG. 1. Section through the eye of *Cryptobranchus Allegheniensis*. *C*, cornea; *Ch*, choroid; *E*, epithelium (conjunctiva); *F*, fold of the retina; G, ganglion-cell layer of retina; *Gl*, gland in the skin near the eye; *I*, iris; *Ig*, ingrowth of choroid into the cartilaginous sclerotic; *L*, lens; *Lc*, lens capsule; *M*, muscles; *Mo*, molecular layer of retina; *N*, inner and outer nuclear layers of retina; *Op*, optic nerve; *P*, pupil; *Pg*, pigmented layer of retina; *Ps*, branched pigment cells; *R*, layer of rods and cones of the retina; *Sc*, cartilaginous sclerotic.

In spite of the fact that the eye seems to have practically no power of motion, there are present the usual muscles, and they are of considerable size; two of them are shown in the figure (*M*).

The choroid (*Ch*) lies in immediate contact with the inner surface of the cartilaginous sclerotic, and is continued in between the front of the lens and the back of the cornea, in the usual

way, to form the iris. It is more or less closely filled with the irregular, black pigment cells that were mentioned in connection with the sclerotic. These cells are seen along the tract of the optic nerve as it passes through the cartilaginous sclerotic. No distinction of layers can be made out in the choroid, nor can a true ciliary process be determined, though a thickening and folding in the region ordinarily occupied by that structure might be interpreted as a ciliary process; no connection of this thickening with the lens can be determined, however, and the appearance of a ciliary process seems to be largely caused by a curious folding of the retina, to be presently described. The reference line *Ch* ends in the thickening just described. In that portion of the choroid that extends in front of the lens to form the iris (*I*) the pigment cells increase to such an extent that the iris is almost or quite black, though this dark color is not so evident in the living eye.

The pupil (*P*) is, as has been said, small and irregular in outline. The retina, though not particularly well fixed in the material studied, shows at least six layers, which may be given the names usually applied to the corresponding structures in other eyes. The outermost (*Pg*) is the pigmented layer; it is comparatively thin, but shows an inner pigmented and an outer nuclear portion. Close to the inner surface of the pigmented layer, though often torn from it, is the layer of rods and cones (*R*); it has been called the layer of rods and cones, though, owing to imperfect fixation, the two structures are indistinguishable. Next to the layer of rods and cones lies a deeply-staining layer (*N*) that, in favorable sections, shows an indistinct division into an outer and an inner zone, which might be called the outer and inner nuclear layers, respectively. The two nuclear layers are composed of similar round, granular elements. Inside of the inner nuclear layer is a finely-granular, nonstaining layer which probably corresponds to the inner molecular layer (*Mo*). The outer molecular layer is not distinguishable in the material at hand. The innermost layer of the retina (*G*), which seems to correspond to the ganglion-cell layer, is composed of a single row of large, rounded or oval elements that stain deeply like the elements of the two nuclear layers. No layer of nerve fibers can

be seen inside of this ganglion-cell layer, nor can the connection of the optic nerve (*Op*) with the retina be determined. The ganglion-cell layer lies, as a rule, in close contact with the lens, so that there is no vitreous cavity ; the narrow space that sometimes appears between the inner layer of the retina and the capsule of the lens is probably due to a slight distortion of the eye.

One of the most striking features of this eye is the large surface covered by the retina ; it extends as is partially shown on the right side of the figure, for some distance in front of the region of the ciliary process, if the thickening of the choroid may be so called. Another striking feature of the retina is the marked fold seen in the region of the ciliary thickening. All of the retinal layers take part in this fold (*F*), which varies somewhat in complexity in different eyes, but is evidently a normal condition and not a mere artifact.

The lens (*L*) presents no striking peculiarities ; it is almost spherical in form, and completely fills the cup of the eye, so that the vitreous cavity, as has been said, is obliterated ; a small space between the front of the lens and the cornea (at the end of the reference line *P*) may, perhaps, be taken to represent the aqueous cavity. The lens is surrounded by a comparatively thick capsule (*Lc*), whose distinctness is somewhat exaggerated in the figure.

The correlation of some of the above-described structures with the habits and mode of life of the giant salamander is not difficult to determine, but in other cases the correlation is not so certain.

The flattened anterior surface of the bulb, for example, is seen in most aquatic amphibia and may be merely a measure of protection against injury by coming in contact with the rocks and other objects under which the animal may hide ; again a flattened or depressed cornea would evidently offer less friction in swimming.

A cartilaginous sclerotic is common among the amphibia, but it is difficult to see the necessity of such a heavily chondrified sclerotic in an eye that is so deeply buried as is this one. The spherical lens resembles the same structure in the teleosts, and probably indicates that the eye is especially adapted to vision at

short range, the lack of transparency of the surrounding medium making long-range vision impossible, in any case. Although no definite experiments have been made along this line by the writer, it seems probable, from general observations, that *Cryptobranchus* is not very keen of sight even at short range.

The slight development of the ciliary process and the apparent absence of the ciliary muscles make it difficult to see how this animal can have any power of accommodation, since there is nothing that corresponds to the processus falciformis of the teleost eye. It is possible, therefore, that objects are clearly seen only when they are at a certain distance from the eye.

The unusually large extent of the retina may be a compensation for the slight power of motion possessed by the eye as a whole, so that the image of an object may fall upon a sensitive surface even though the object be without the ordinary line of vision.

The absence of the vitreous chamber may be correlated with the unusual refractive power of the lens, which makes a further refractive medium unnecessary, and necessitates the shortening of the eye-ball to bring the retinal surface to the focus of the highly-refractive lens.

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